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Maine Agricultural Experiment Station

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WHEATS AND FLOURS OF AROOSTOOK COUNTY.

This bulletin contains the chemical analyses of Maine wheats and the flours made from them, experiments upon the effects of climate upon wheat, milling experiments of Maine and northwestern grown wheats with baking tests of the flours, and a comparison of the wheats and flours of Aroostook county with those of the Northwest.

Requests for bulletins should be addressed to the
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NOTES AND EXPERIMENTS UPON THE WHEATS AND FLOURS OF AROOSTOOK COUNTY.

Chas. D. Woods and L. H. Merrill.

Since the introduction of roller mills into this State, wheat growing in Aroostook county has received a marked impetus. Several years ago the attention of the Station was drawn to the subject and a brief study of the wheats and flours produced in the county was undertaken. Although it was found necessary to discontinue this work before many definite conclusions could be reached, considerable data have been accumulated that are given here as a report of progress. The work accomplished has been made possible through the effective co-operation of growers and millers. We are especially indebted to Mr. T. H. Phair of Presque Isle, and his miller, Mr. Carter, and also to E. Merritt and Sons of Houlton, and their miller, Mr. H. P. Gray.

The first roller flour mill in Aroostook county was built in 1897 by D. E. Edwards of Fort Kent. Although this was not a large mill, having a daily capacity of only fifty barrels, its establishment may be considered as marking an era of considerable importance in the industrial and agricultural development of the State. Since the date mentioned five other roller mills have been built in the county, so that at present there are six mills, as follows:

D. E. Edwards, Fort Kent, capacity	50 barrels
H. D. Collins, Caribou, capacity	50 barrels
H. A. Edwards, Caribou, capacity	30 barrels
Alexander Cox, Presque Isle, capacity	50 barrels
T. H. Phair, Washburn, capacity	20 barrels
E. Merritt & Sons, Houlton, capacity	50 barrels

The combined capacity of these mills is 250 barrels per day, or about 75,000 barrels per year.

It is estimated that the American people consume annually 357 pounds of bread per capita.* This is equivalent to about 260 pounds of flour, or one and one-third barrels. In dietary studies of the inmates of the hospitals of the insane of New York state † it was found that 10 hospitals with nearly 25,000 patients and attendants, used a total of 6,000,000 pounds of flour. This is equivalent to 240 pounds, or one and one-fourth barrels of flour for each person.

Assuming the accuracy of these figures from two distinct sources, the 60,000 people of Aroostook county could use all the flour which the mills now established there could produce. These mills, however, are not run at anything like their full capacity. The wheat crop of 1901 was probably as large as any that Aroostook county has harvested, yet even this crop was not sufficient to employ these mills to more than one-third their capacity.

The essential difference between these mills and the larger establishments of the Northwest is in the number and size of the stands, the consequent number of breaks, and the closeness with which the final products are graded. With a good quality of wheat and expert milling these mills should turn out as good product as larger plants.

Aroostook Flour Compared with Western Flour.

In 1900 the Station collected and analyzed samples of flour from three of the mills in Aroostook county. The tables which follow give the results of the analyses of these flours together with those of the samples since received from the mills of E. Merritt and Sons of Houlton, and of six samples of three brands of flours milled at Minneapolis. In the first table the results are calculated to the water content of the flours as received at the laboratory. As the flours vary somewhat in the amount of water which they contain, the results are calculated in the second table to a water-free basis.

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* American Miller, March 1, 1901.

† W. O. Atwater, Report of Dietaries for Hospitals for the Insane, 10th Annual Report of the New York State Commission in Lunacy.

COMPOSITION AND HEAT OF COMBUSTION OF AROOSTOOK FLOURS COMPARED WITH WESTERN FLOURS. RESULTS CALCULATED TO WATER CONTENT OF FRESH FLOURS.

Laboratory number.	Manufacturers and Brands.	Water.	Nitrogen.	Protein (Nx5.7).	Fat.	Crude fiber.	N-free extract.	Ash.	Heat of combustion per gram.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Calories
	Aroostook County.								
6302	S. W. Collins & Sons, Straight..	11.57	1.49	8.49	1.50	.23	77.70	.51	3.839
6306	S. W. Collins & Sons, Aroostook Patent	12.75	1.55	8.83	1.12	.17	76.93	.38	3.805
6296	T. H. Phair, Straight	14.38	1.55	8.83	1.49	.16	74.55	.59	3.768
6349	T. H. Phair, First Grade	12.91	1.84	10.49	.96	.36	74.85	.43	3.864
6356	T. H. Phair, First Grade	13.57	1.64	9.35	1.09	.27	75.28	.44	3.805
6413	E. Merritt & Sons	10.73	1.63	9.29	1.20	.26	78.08	.45	3.865
6414	E. Merritt & Sons	13.83	1.73	9.86	1.23	.22	74.38	.48	3.821
6415	E. Merritt & Sons	14.68	1.52	8.66	1.07	.27	74.86	.46	3.783
6608	E. Merritt & Sons, Patent	13.62	1.53	8.72	1.09	.16	75.97	.44	3.723
6609	Second Grade	12.70	1.83	10.43	2.15	.37	73.30	1.05	3.824
6613	Patent	14.84	1.51	8.61	.79	.24	75.20	.32	3.660
6614	Second Grade	15.20	1.77	10.09	.63	.39	72.98	.71	3.639
6618	Patent	13.57	1.75	9.97	1.21	.25	74.47	.53	3.734
6619	Second Grade	13.68	1.95	11.11	.51	.42	73.39	.89	3.706
6623	Patent	12.19	2.27	12.94	1.04	.19	73.12	.52	3.831
6624	Second Grade	12.44	2.53	14.42	2.03	.45	69.66	1.00	3.886
6628	Patent	12.13	2.05	11.69	1.12	.18	74.52	.36	3.812
6629	Second Grade	12.14	2.35	13.40	2.30	.48	70.48	1.20	3.831
	Average of Aroostook County flours	13.16	1.80	10.29	1.25	.25	74.45	.60	3.789
	Average of 8 flours from Maine grown wheats*	13.50	1.60	9.12	1.13	.24	75.52	.49	3.773
	Western.								
6129	Pillsbury's Best	13.78	1.97	11.23	1.40	.....	73.01	.58	.....
6130	Pillsbury's Best	11.84	2.21	12.60	1.25	.....	73.81	.50	.....
6133	N. W. Consolidated Milling Co., Straight	11.55	2.04	11.63	1.43	.....	74.79	.60	3.889
6273	N. W. Consolidated Milling Co., Straight	11.30	2.04	11.63	1.28	.33	75.02	.44	3.942
6443	N. W. Consolidated Milling Co., Straight	10.90	2.27	12.94	1.40	.35	73.92	.49	3.963
6382	Washburn-Crosby Co., First Grade	12.41	2.01	11.46	1.74	.27	73.70	.42	3.876
	Average of Western flours	11.96	2.09	11.92	1.42	.32	73.88	.50	3.917

*See discussion on page 148.

COMPOSITION AND HEAT OF COMBUSTION OF AROOSTOOK COUNTY FLOURS COMPARED WITH WESTERN FLOURS. RESULTS CALCULATED TO A WATER-FREE BASIS.

Laboratory number.	Manufacturers and Brands.	Nitrogen.	Protein (Nx5.7)*	Fat.	Crude fiber.	N-free extract.	Ash.	Heat of combustion per gram.
	Aroostook County.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Calories.
6302	S. W. Collins & Son, Caribou, Straight	1.68	9.58	1.70	.26	81.89	.57	4.293
6306	S. W. Collins & Son, Aroostook Patent	1.78	10.15	1.28	.20	87.94	.43	4.361
6296	T. H. Phair, Washburn, Straight	1.81	10.32	1.74	.19	87.07	.68	4.401
6349	T. H. Phair, First Grade	2.11	12.03	1.10	.41	85.97	.49	4.437
6356	T. H. Phair, First Grade	1.90	10.83	1.26	.31	87.09	.51	4.402
6413	E. Merritt & Sons, Houlton	1.83	10.43	1 34	.29	87.44	.50	4.330
6414	E. Merritt & Sons	2.01	11.46	1.43	.25	86.30	.56	4.434
6415	E. Merritt & Sons	1.78	10.15	1.25	.32	87.76	.54	4.434
6608	E. Merritt & Sons, Patent	1.77	10.09	1.26	.18	87.96	.51	4.312
6609	Second Grade	2.10	11.97	2.46	.42	83.95	1.20	4.380
6613	Patent	1.77	10.09	.93	.28	88.32	.32	4.298
6614	Second Grade	2.09	11.91	.74	.46	86 05	.84	4.292
6618	Patent	2.03	11.57	1.40	.29	86.13	.61	4.321
6619	Second Grade	2.26	12.88	.59	.49	85.01	1.03	4.294
6623	Patent	2.59	14.76	1.18	.22	83.25	.59	4.363
6624	Second Grade	2.89	16.47	2.32	.51	79.56	1.14	4.338
6628	Patent	2.33	13.28	1.27	.21	84.83	.41	4.338
6629	Second Grade	2.68	15.28	2.62	.55	80.18	1.37	4.360
	Average of Aroostook County flours	2.08	11.86	1.44	.32	85.69	.69	4.355
	Average of 8 flours†	1.84	10.49	1.30	.28	87.37	.56	4.355
	Western.							
6129	Pillsbury's Best	2.29	13.05	1.62	.....	‡84.65	.68	
6130	Pillsbury's Best	2.51	14.31	1.42	.....	‡83.70	.57	
6133	N. W. Consol. Milling Co., Straight	2.31	13.17	1.61	.....	‡84.51	.68	4.397
6273	N. W. Consol. Milling Co., Straight	2.30	13.11	1.44	.37	84.58	.50	4.444
6443	N. W. Consol. Milling Co., Straight	2.55	14.54	1.57	.39	82.95	.55	4.448
6382	Washburn-Crosby Co., First Grade	2.30	13.11	1.98	.31	84.12	.48	4.426
	Average of Western flours	2.37	13.51	1.61	.36	83.94	.58	4.429

* The factor 5.7 is used throughout this bulletin in calculating the percentage of protein as this more nearly represents the relation of nitrogen to protein in wheat than the usual factor, 6.25.

† See discussion which follows the table.

‡ Total carbohydrates.

In the second of the preceding tables, the average amount of protein in the Maine flours is shown to be 1.65 per cent below that of the western flours. The comparison is not a fair one, however, since four of the Aroostook flours, 6349, 6356, 6628, and 6629, were from western grown wheats Six of the others, 6608, 6609, 6618, 6619, 6623 and 6624, were from wheats of western parentage which had been grown but one year in this State. If we exclude these ten flours from our averages, we find that the remaining eight Maine flours, water-free, contain three per cent less protein than the western. In other words, the western flours contain one-fourth more protein than those ground in Aroostook county from home grown wheats.

If we continue the comparison, we note also that the dry matter of the western flour contains one-fourth more fat and crude fiber, and three and one-half per cent less starch and other carbohydrates than the Maine flour. The heat of combustion is practically the same in both.

These differences may be summed up by saying that the dry matter of these Maine flours contained three per cent less protein, three per cent more carbohydrates (mostly in the form of starch), and slightly less fat and woody matter than the hard wheat flours of the Northwest.

BAKING TESTS OF AROOSTOOK MILLED FLOURS.

Six of the samples of flour, analyses of which are given in the preceding tables, were sent to Mr. C. E. Foster, the milling expert of the Northwestern Consolidated Milling Company of Minneapolis. This is one of the largest flour milling companies of the world, and twice daily makes baking tests on all its output. Mr. Foster kindly examined these flours and his report is summarized in the following table. As the terms in which the results are given are somewhat unfamiliar, they are explained in detail in the discussion which follows the table.

RESULTS OF BAKING TESTS OF AROOSTOOK FLOURS.

Number of sample.	Appearance of Flour.	Dough.		Bread.				Moist gluten.
		Viscosity.	Color.	Largest circumference of loaf.	Least circumference of loaf.	Weight.	Color.	
				Inches.	Inches.	Ounces.		Per cent.
6306	....	....	1	27.00	22.60	18.00	.....	27.50
6349	Coarse.....	Very short..	1xw	27.75	24.00	18.50	.....	32.29
6356	Coarse.....	Very short..	1w	27.50	24.00	18.25	.....	28.12
6413	Very soft.....	Short	1w	25.25	21.00	17.75	1—	29.58
6414	Granular, coarse ...	Fair, Elastic	1	26.50	23.00	18.50	1	29.58
6415	Mixed	Soft	1.5	26.00	22.25	17.75	1.5	26.04
	Minn. Standard....	Standard ...	1	29.25	26.25	18.25	1	38.75

The Northwestern Milling Company has adopted a standard flour as an ideal toward which it works. In appearance of the flour, viscosity and color of the dough, and color of the resulting bread, the standard is taken as unity. The standard carries 38.75 per cent of wet gluten. In the narrow pans in which the bread is baked, 12 ounces of flour should produce a loaf weighing 18.25 ounces and measuring in its greatest circumference 29.25 inches, and over the center of the loaf at right angles to this, 26.25 inches.

The standard flour is of a degree of fineness which has been found by experience to produce the best loaf. It is not granular, nor is it impalpable. The standard is thoroughly uniform in appearance. Its degree of fineness is so definite, and the sense of touch of the expert so delicate that he is at once able to properly class a flour. "Soft" means ground too fine for bread purposes. Sample 6414, while too granular, was "nearest Minneapolis first patent in granulation." Sample 6415 was reported as "mixed." This means that the flour from the different breaks was not of uniform fineness, so that the resultant flour from the breaks was of uneven fineness.

When the standard flour is wet up so as to make a dough, it has a definite viscosity. If a dough has not as great resistance to the touch as the standard it is "soft." If it has less tenacity than the standard, it is "short." A soft or short dough will also have less elasticity than the standard. Sample No. 6414 was nearer to the standard Minneapolis patent than any of the other flours in viscosity and color of the dough.

The scale used in marking the color of the dough is as follows: 1 x w indicates dead white rather than the creamy white of the Minneapolis Standard patent. 1 w means that the dough is white but not such a dead white as 1 x w.

In the color of the bread, 1- means that the bread is just a little off color for a patent, while 1.5 means that it has the color of a straight grade and not that of a patent flour.

The wet or moist gluten is determined by taking a definite weight of flour, wetting it to a dough and with the necessary precautions washing out the starch and soluble constituents by kneading and working the materials under a stream of water. Crude as this separation is, in the hands of an expert it gives results which, when made by the same person, are closely com-

parable. It is noted that all of these Maine milled flours were very deficient in the content of wet gluten as compared with the standard Minneapolis first patent. While the defect may be due to a lower gluten content in Maine grown wheats, it would seem that a large part of it is due to milling. Samples 6349 and 6356 were made from carefully bred Minnesota wheat. There is little doubt that if these same wheats had been milled by the expert millers of the Consolidated Milling Company in their large plant that the resultant flours would have been equal to the Minneapolis standard. In other words, the Maine miller did not work as close to the outer layers of the wheat berry as the western miller would have done.

By referring to the percentage of protein given in the tables on pages 147 and 150 it will be seen that there is in general a fair conformity between the amount of protein and that of wet gluten.

The standard flour produces a loaf of maximum weight and size from a given weight of flour. Both of these factors are largely dependent upon the amount of gluten which the flour carries. While experiments by Snyder * indicate that in a flour of the highest bread making properties there is a definite ratio of gliadin to glutenin (the two substances which together constitute gluten), these particular flours were not examined for these constituents.

It will be noted that while most of these Maine milled flours gave a loaf nearly equal to or greater in weight than the standard flour, that the loaf as shown by its measurements was considerably smaller. This means that the bread was heavy as compared with the Minneapolis standard described on page 150. The bread from 6415 while giving a loaf of low weight, a drawback from the baker's standpoint, was large in proportion to its weight, and so far as texture and appearance were concerned, the expert had no criticism to offer. It is interesting to note that this flour, which from the standpoint of the consumer was the best of any of the Maine flours, was made from wheat which had been grown for many years in Aroostook county. The report of the expert shows that the flours depart from the Minneapolis standard in appearance, in working and in baking.

The imperfect and uneven granulation are due to faulty milling and can, of course, be corrected, at least, in part, although it

* Bul. 101, Office of Experiment Stations, U. S. Dept. Agr., p. 61.

may not be possible in small mills to adopt all the refinements practiced in large establishments, partly for lack of machinery, and partly because expert millers cannot be profitably employed where the business is small. The report shows that, in addition to the ordinary defects in milling, the flours were somewhat deficient in gluten; in other words, the flours were weak.

The two lots of Minneapolis grown wheat milled at Washburn were lower in protein than the flours from this wheat should have been, but they carried considerably more protein than the flours made from Maine grown wheat. While the amount of gluten in the flour is to a certain extent determined by the process of milling, in which matter may be excluded that should have been retained in the flour, the deficiency in the cases examined is so large that it can only to a limited extent be referred to this source and must rather be attributed to a lack of gluten in the grain itself.

Composition of Maine Grown Wheat.

The low protein content of the Maine flours naturally led to the examination of several wheats grown in Aroostook county. Numerous studies have been made elsewhere upon the general effect of climate upon the size and composition of the wheat berry. The present studies can be better interpreted in the light of these other investigations. The summaries of such studies by a few authorities follow.

EFFECTS OF CLIMATE UPON WHEAT.

Schindler * has shown that the size and weight of the berry of wheats of different localities depends upon the length of the vegetation period, and more especially upon the length of the interval between blossoming and ripening. This, as he explains, is in accordance with the development of the grain as it matures, which is as follows: The glumes or chaff of the berry are first in order of growth; following these, the outer fruit coating and then the inner true seed coats develop, then follows the endosperm which is the richest in gluten, and later still the storage tissues in the interior of the berry are formed. In regions with a moist warm climate the fruiting period is prolonged and abundant quantities of starch are formed in the large leaf sur-

* Der Weizen in seinen Beziehungen zum Klima, u. s. w., Berlin, 1893.

faces which such a climate produces on the wheats. The starch thus formed is all transferred to the berry, which is thus filled up as is shown externally by the broadly expanded form. Such a wheat is relatively rich in carbohydrates and poor in protein.

On the other hand, a hot dry climate shortens the time for starch transference, and the native wheats of such a climate are in general richer in protein and lower in carbohydrates. As illustrations of this, he shows that the climate, and especially proximity to the sea, closely affects the amount of gluten in the wheat. The insular climate of England produces a robust wheat having large ears with numerous kernels but with less gluten than the wheats of eastern Europe. According to this author, the wheats of England and other countries having a similar climate seldom contain more than ten per cent of gluten; while in the warm temperate zone, in eastern Europe, as well as in the Western United States, in Southern Russia, Roumania, and Turkey, and in the subtropical zone, the gluten content may even exceed twenty per cent.

The wheats from different sections of our own country show a great variation in the protein content.*

PROTEIN IN AMERICAN WHEATS.

Section.	Number of analyses.	Average per cent.	Highest per cent.	Lowest per cent.
Atlantic and Gulf States	117	11.35	15.58	9.43
Middle States	91	12.50	16.63	10.15
Western States	177	12.74	18.03	8.93
Pacific States	20	9.73	12.78	7.70
Canada	6	10.87	14.70	9.45

These figures show an extreme range of over 10 per cent, from 18.03 per cent in the western states to 7.70 per cent in the Pacific states. It is not to be understood that these variations are due to difference in climate alone. On the contrary, the varieties grown, nature of the soil, and the kind of fertilizers used, have

* Report of Chemist, U. S. Dept. Agr., Rept. 1884, p. 77.

all been proved to have their influence. Since, however, the figures of Richardson represent a large number of analyses it must be admitted that the predominating influences are climatic. These conclusions are not in thorough accord with those of Wiley * who asserts that "the broad principle has been established that, other things being equal, wheats from a high northern latitude contain more gluten than those grown farther south and the wheats that are grown in the spring a larger quantity of gluten than those which are planted in the autumn." Brewer † states that the quality of wheat is largely determined by climate, the grain of a sunny climate, like that of California, Egypt, northern Africa, and similar countries always ranking high for quality. He finds no proof, however, for the frequent assertion that such wheats are richer in gluten and consequently make stronger flours. Chemical composition depends more upon the variety cultivated than upon soil or climate, although the influence of the two latter is by no means to be overlooked. "Many years ago Davy found the wheat of Sicily richer in gluten than that of England, and this appears to have led to a hasty generalization that the wheat of warm climates was stronger than that of cooler ones. It has been claimed that the wheat of northern Africa was stronger, that is, contained more gluten, than that of northern Europe. So far as our analyses of American wheat show, this has not proved to be the case here. Undoubtedly climate as well as soil affect the amount of albuminoids, but we have no evidence that California wheats are, as a class, richer than those of the other regions, or the wheats of the southern states richer than those of the northern." ‡

We find, then, quite a marked difference of opinion regarding the relations between quality of wheat and climate. This confusion is not so surprising when we consider how many factors enter into the problem. It is manifestly unfair to compare wheat from different localities when the varieties grown are not the same. Thus, wheats of the varieties, French Imperial and New York Spring wheat, grown upon the farm of the Oregon Agricultural College in the same season, 1889, were found to contain respectively 1.35 and 2.21 per cent nitrogen; that is one con-

* U. S. Department of Agriculture, Yearbook 1899, p. 244.

† Tenth Census U. S., 1880, Vol. III, Cereal Production of the U. S., p. 64.

‡ Brewer. Tenth Census of the U. S., 1880, Vol. III, Cereal Production U. S., p. 68

tained over 60 per cent more nitrogen than the other.* The table which follows contains the results of the analyses of 16 samples of spring wheat grown in northern Maine (Aroostook county). Twelve samples of hard spring wheat grown in the northwest have recently been analyzed at the Station. These results are given in the table for purposes of comparison. In this table is also given the average of 25 analyses of Minneapolis wheats reported by the Minnesota Experiment Station. As there reported, the protein was calculated by using the factor 6.25. It is here recalculated, using 5.7 as a factor.

THE COMPOSITION AND HEAT OF COMBUSTION OF SPRING WHEAT GROWN IN MAINE COMPARED WITH WHEAT GROWN IN THE NORTHWEST. CALCULATED TO WATER CONTENT OF FRESH WHEAT.

Laboratory number.	Variety of Wheat.	Wt. 100 kernels.	Water.	Nitrogen.	Protein (Nx5.7)	Fat.	Crude fiber.	N-free extract.	Ash.	Heat of combustion per gram.
	Grown in Aroostook County.	Grms	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Calories.
6294	Unknown	3.245	11.67	1.74	9.92	2.65	2.32	71.43	2.01	3.924
6301	Unknown	3.333	11.82	1.93	11.00	2.68	2.00	70.69	1.81	3.918
6317	Lost Nation	3.218	11.70	1.66	9.46	1.97	2.21	72.97	1.69	3.884
6410	White Fife	3.075	9.62	2.04	11.63	2.22	2.47	72.27	1.79	3.989
6411	Common Aroostook	2.825	9.35	1.86	10.60	2.22	2.50	73.48	1.85	4.005
6412	Blue Stem	3.228	9.28	1.96	11.17	2.28	2.52	72.96	1.79	3.994
6431	Hard Fife	3.379	11.12	1.93	11.00	2.25	2.28	71.62	1.73	3.966
6432	White Russian	3.262	12.22	1.85	10.54	2.17	2.41	70.99	1.67	3.909
6433	Blue Stem	2.977	11.41	1.88	10.72	2.25	2.42	71.31	1.89	3.932
6434	Fife	3.178	9.42	2.07	11.80	2.32	2.65	71.94	1.87	3.998
6435	Blue Stem	2.970	9.14	1.86	10.60	2.25	2.40	73.82	1.79	3.988
6436	Unknown	3.032	10.16	1.78	10.15	2.26	2.56	73.12	1.75	3.997
6437	Unknown	3.969	9.74	2.15	12.25	2.23	2.52	71.24	2.02	3.990
6438	Unknown	3.084	9.82	1.83	10.43	2.31	2.55	72.93	1.96	3.977
6439	Unknown	3.578	11.33	1.87	10.66	2.24	2.42	71.65	1.70	3.926
6440	Blue Stem	3.251	11.15	2.21	12.60	2.29	2.31	69.96	1.69	3.922
	Average of 16 wheats	3.225	10.56	1.91	10.91	2.29	2.41	72.02	1.81	3.957
	Grown in the Northwest.									
6270	Hard Spring	2.371	11.19	2.20	12.54	2.43	1.96	70.23	1.65	3.987
6310	Wellman's Fife	2.129	11.84	2.16	12.31	2.22	2.66	69.11	1.86	3.954
6314	Fife	2.203	10.93	2.15	12.26	1.98	2.52	70.11	2.10	3.919
6315	Blue Stem	2.213	11.72	1.78	10.15	2.07	2.67	71.41	1.98	3.891
6316	Blue Stem	2.253	9.59	2.21	12.60	2.05	2.65	70.93	2.18	3.995
6348	Wellman's Fife	2.271	12.80	2.06	11.74	2.53	2.46	68.35	2.12	3.956
6355	Blue Stem	2.199	12.48	1.86	10.60	2.30	2.42	70.36	1.84	3.909
6516	Hard Spring	2.604	12.08	2.39	13.62	2.70	2.40	67.21	1.99	3.969
6622	Blue Stem	3.087	10.89	2.55	14.54	2.11	2.17	68.42	1.87	3.936
6627	Unknown	2.474	11.39	2.32	13.22	2.32	2.35	68.74	1.98	3.823
6714	Minn. No. 181	2.527	10.80	2.97	16.93	1.99	2.30	66.02	1.96	3.890
6715	Minn. No. 851	2.440	10.03	2.47	14.08	2.23	2.50	69.17	1.99	3.996
	Average of 12 wheats	2.398	11.31	2.26	12.88	2.24	2.45	69.16	1.96	3.935
	Average of 25 analyses of Minnesota wheats †	.....	11.00	2.20	12.54	2.05	2.25	70.24	1.92	

† Bulletin 36 Minnesota Experiment Station.

* Oregon Expt. Sta., Bul. 4, p. 31.

Because of the hot, dry summer, the growing season of the northwest is much shorter than in Aroostook county. Wheat harvest is from a month to six weeks earlier in Minnesota than in Maine. For this reason we should expect a difference in the size and composition of the berry. In the sixteen samples of Aroostook wheats the weight of 100 kernels varied from 2.825 to 3.969 grams, averaging 3.225 grams. The eight northwestern wheats showed a greater uniformity in size, 100 kernels ranging from 2.129 to 3.087 grams, with an average of 2.398. Omitting sample 6622, the range was from 2.129 to 2.604 grams. This difference in weight was accompanied by a difference in composition, the difference being chiefly in the lower protein and higher nitrogen-free extract of the Maine wheats. This difference is more clearly brought out in the following table, where the analyses of the different wheats are calculated to a water-free basis.

AVERAGE COMPOSITION AND HEAT OF COMBUSTION OF MAINE AND WESTERN GROWN WHEATS, CALCULATED TO A WATER-FREE BASIS.

		Nitrogen.	Protein (Nx5.7)	Fat.	Crude fiber.	N-free extract.	Ash.	Heat of combustion per gram.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Calories.
16	Maine wheats	2.14	12.20	2.56	2.70	80.52	2.02	4.424
12	Western wheats	2.55	14.52	2.53	2.76	77.98	2.21	4.437
25	Minnesota wheats	2.47	14.09	2.30	2.53	78.92	2.16	*4.328

*Calculated.

Experiments upon Growing Northwestern Wheats in Maine.

Marked as are the differences in composition of wheats that have been grown many years in Aroostook county, the immediate effect of change of climate upon carefully bred wheat is not so clear. It is important for the Maine grower to produce a wheat with as high a protein content as possible. Practical men in Aroostook county are unanimous in the opinion that wheats grown from western seed change in size and appearance of the

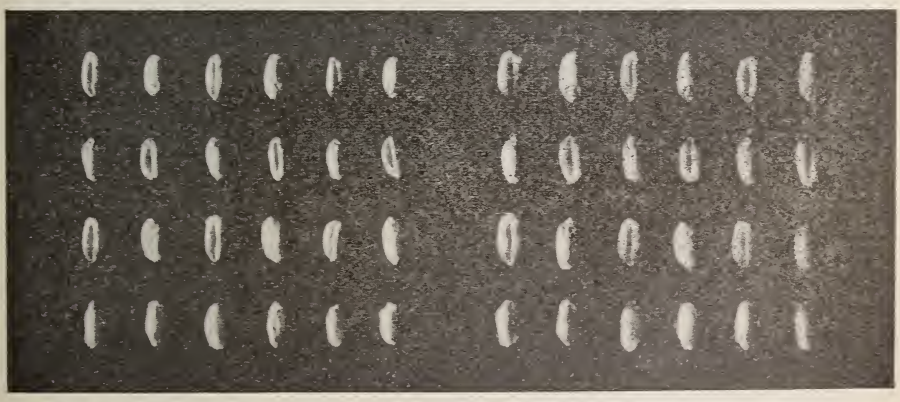
kernel. How soon this change takes place, whether in one or two seasons, or whether more gradually is not clear.

FIRST EXPERIMENT.

As a preliminary study, three experiments in growing wheat in Aroostook county from western seed were made in 1900. While three trials in one season are not sufficient to give conclusive results, they were undertaken with the hope that they might prove to be instructive as indications of what might be expected from more extended trials. The description of the seed and details of the experiment follow.

6309. Lamona wheat, obtained from the U. S. Department of Agriculture. This wheat was grown in Lincoln county, Washington, and is said to be the best drouth-resistant variety ever grown there, yielding from 20 to 30 bushels per acre of fine plump kernels. A portion of this wheat was reserved for analysis, and the remainder forwarded to the Hon. T. H. Phair of Presque Isle, to be used as seed. Samples were obtained from the crop thus grown (6515).

FIG. 52. FIFE WHEAT, SHOWING CHANGES IN SIZE AND SHAPE OF KERNEL BY CHANGE OF CLIMATE.



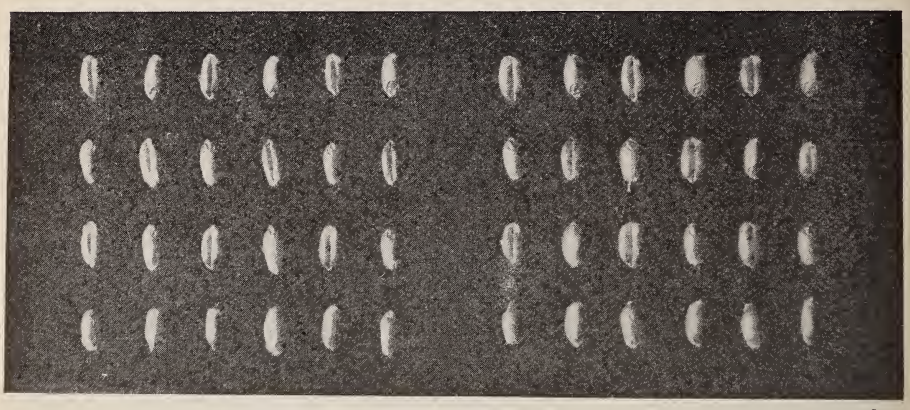
6314. Parent, Minnesota grown. 6434. Progeny, Maine grown.

6314. Wellman's Fife. This wheat was obtained from Professor W. M. Hays of the Minnesota Experiment Station. It was grown at Perham, Minn., from seed introduced 20 years previously from the Saskatchawan Valley. It is thought to have come originally from northern Russia. From this seed crops were grown at several points in Aroostook county. Sample 6434 was grown at Washburn by Alex Duncan.

6315. Blue Stem Wheat. This was also obtained from Professor Hays. It was grown in Minnesota from seed introduced over 20 years before from North Dakota. This is one of the superior hard wheats of Minnesota. A crop from this seed was grown by John H. Wark of Washburn, from which sample 6435 was selected.

A considerable amount of grain of the two varieties last named which had been purchased by Mr. Phair for seed remained unsold and was ground at Mr. Phair's mill at Washburn. At the same time samples of grain grown in Aroostook county from this seed were also ground. Opportunity was thus furnished for comparing not only the wheats themselves but the resulting flours.

FIG. 53. BLUE STEM WHEAT, SHOWING CHANGES IN SIZE AND SHAPE OF KERNEL BY CHANGE OF CLIMATE.



6315. Parent, Minnesota grown. 6435. Progeny, Maine grown.

The tables on page 159 contain the results of the analyses of these grains. An examination of the first column of the table on the top of the following page shows an increase in the weight of the kernel in each case. With the Fife and Blue Stem the increase was very large (see accompanying illustrations), amounting to nearly 50 per cent of the seed, while the weight of the Lamona kernel (already very heavy) remained practically unchanged. The latter, however, showed a very marked decrease in protein, amounting to 21 per cent of the original. The Fife also suffered a small loss of protein, while the Blue Stem made a slight gain, too small to be of any significance. All the wheats exhibited a remarkable agreement in the heats of combustion.

A COMPARISON OF MAINE GROWN WHEATS WITH THE WESTERN GROWN SEED. CALCULATED TO A WATER-FREE BASIS.

Laboratory number.		Weight 100 kernels.	Nitrogen.	Protein (N×5.7)	Fat.	Crude fiber.	N-free extract.	Ash.	Heat of combustion per gram.
	Lamona.	Grms	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Calories.
6309	Western	3.143	2.78	15.87	1.98	2.31	77.85	1.99	4.491
6515	Aroostook	3.225	2.17	12.37	3.28	2.77	79.60	1.98	4.402
	Fife.								
6314	Western	1.962	2.41	13.75	2.23	2.94	78.72	2.36	4.400
6434	Aroostook	2.879	2.29	13.03	2.56	2.93	79.41	2.06	4.415
	Blue Stem.								
6315	Western	1.954	2.02	11.51	2.35	3.02	80.88	2.24	4.406
6435	Aroostook	2.699	2.05	11.69	2.48	2.64	81.22	1.97	4.388

PERCENTAGE AMOUNTS OF PROTEIN AND WET AND DRY GLUTEN IN WESTERN WHEATS AND THEIR MAINE GROWN PROGENY.

Laboratory number.		Protein.	Wet gluten.	Dry gluten.	Ratio wet to dry gluten.
	Lamona.	Per cent.	Per cent.	Per cent.	
6309	Western	15.87	40.92	15.38	2.66:1
6515	Aroostook	12.37	26.83	11.42	2.35:1
	Fife.				
6314	Western	13.75	26.66	10.95	2.43:1
6434	Aroostook	13.03	28.65	11.31	2.53:1
	Blue Stem.				
6315	Western	11.51	24.07	9.92	2.42:1
6435	Aroostook	11.69	27.60	11.32	2.44:1
					2.47:1

The Lamona suffered a large falling off in protein and a still larger loss in the gluten content. On the other hand, both the other varieties gained in gluten, the Maine wheats being stronger than the western seed. Even the Fife, which lost .73 per cent protein, gained .36 per cent dry gluten, showing that the usual relations between protein and gluten are reversed. These results are somewhat surprising and fail to confirm the conclusions reached from the comparison of flours previously made. It should be remarked, however, that the loss of gluten in the Lamona is much larger than the combined gains of the other varieties.

SECOND EXPERIMENT IN GROWING NORTHWESTERN WHEAT IN MAINE.

The results of the first trial were so contradictory that a second series was planned under other and more favorable conditions.

Through the courtesy of Mr. John Watson the Station grew in 1902 five one-fourth acre plots of wheat on his farm in Houlton. In 1901 E. Merritt & Sons imported a car of Blue Stem wheat from the Northwest, part of which they sold for seed. A milling test (described beyond) was made with this original wheat and with its Maine grown progeny, and both this original wheat and the Maine grown were selected for the experiment. Professor W. M. Hays of the Minnesota Experiment Station kindly furnished us with two strains of Blue Stem wh at bred by them and also grew plots of the same on the Minnesota Station farm for comparison. The relation between the parent wheats and their progeny is shown in the table at the top of page 161.

The composition of these wheats, both parent and progeny, is given in the tables on pages 161 and 162, where the wheats are classified according to the locality in which they were grown. Beyond these tables of composition are given the more characteristic figures arranged in order of growth.

TABLE SHOWING THE RELATIONS BETWEEN THE SEED WHEAT AND THE PROGENY.

Parent Wheats.	Progeny. 1901.	Progeny. 1902.
No. 6622. Blue Stem 1900. Northwestern.	No. 6617. From No. 6622. Aroostook County.....	No. 6770. From No. 6617. Aroostook County.
	.....	No. 6772. From No. 6622. Aroostook County.
No. 6714. Minn. 181. Northwestern 1901.	.....	No. 6774. Northwestern.
	.....	No. 6769. Aroostook County.
No. 6715. Minn. 851. Northwestern 1901.	.....	No. 6775. Northwestern.
	.....	No. 6768. Aroostook County.

COMPOSITION AND HEAT OF COMBUSTION OF SPRING WHEATS GROWN IN THE NORTHWEST COMPARED WITH THE SAME VARIETIES GROWN IN AROOSTOOK COUNTY.

Laboratory number.	Variety of Wheat.	Wt. 100 kernels.	Water.	Nitrogen.	Protein (Nx5.7)	Fat.	Crude fiber.	N-free extract.	Ash.	Heat of combustion per gram.
	Northwestern.	Grms	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Calories.
6622	Blue Stem	3.087	10.89	2.55	14.54	2.11	2.17	68.42	1.87	3.936
6714	Minn. 181	2.527	10.80	2.97	16.93	1.99	2.30	66.02	1.96	3.890
6774	Minn. 181	2.230	12.07	2.26	12.88	2.52	2.69	67.77	2.05	3.862
6715	Minn. 851	2.440	10.03	2.47	14.08	2.23	2.50	69.17	1.99	3.996
6775	Minn. 851.....	2.312	11.93	2.39	13.62	2.52	2.95	66.76	2.22	3.886
	Average of 5.....	2.519	11.14	2.53	14.41	2.27	2.52	67.63	2.02	3.914
	Aroostook County.									
6617	Blue Stem	3.329	13.58	1.89	11.01	2.14	2.14	69.53	1.60	3.823
6770	Blue Stem	3.435	11.77	2.41	13.74	2.10	1.85	68.44	2.10	3.965
6772	Blue Stem	3.751	11.65	2.41	13.74	2.10	2.11	68.47	1.93	3.898
6769	Minn. 181.....	3.784	12.27	2.41	13.74	2.33	2.03	67.77	1.86	3.917
6768	Minn. 851.....	3.860	12.53	2.47	14.08	2.14	2.19	67.02	2.04	3.902
	Average of 5.....	3.625	14.36	2.32	13.21	2.16	2.06	66.29	1.91	3.901

COMPOSITION AND HEAT OF COMBUSTION OF SPRING WHEATS GROWN IN THE NORTHWEST COMPARED WITH THE SAME VARIETIES GROWN IN AROOSTOOK COUNTY. CALCULATED TO A WATER-FREE BASIS.

Laboratory number.	Variety of Wheat.	Wt. 100 kernels.	Nitrogen.	Protein (Nx5.7).	Fat.	Crude Fiber.	N-free extract.	Ash.	Heat of combustion per gram.
	Northwestern.	Grms	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Calories.
6622	Blue Stem	2.751	2.86	16.32	2.37	2.44	76.78	2.09	4.417
6714	Minn. 181	2.254	3.33	18.98	2.23	2.58	74.02	2.19	4.361
6774	Minn. 181	1.960	2.57	14.65	2.87	3.06	77.08	2.33	4.392
6715	Minn. 851	2.196	2.75	15.65	2.48	2.78	76.89	2.21	4.442
6775	Minn. 851	2.036	2.71	15.46	2.86	3.35	75.81	2.52	4.409
	Average of 5	2.239	2.85	16.22	2.55	2.84	76.12	2.27	4.405
	Aroostook County.								
6617	Blue Stem	2.877	2.18	12.76	2.48	2.48	80.43	1.85	4.425
6770	Blue Stem	3.031	2.73	15.57	2.38	2.10	77.57	2.38	4.494
6772	Blue Stem	3.314	2.73	15.55	2.38	2.39	77.50	2.18	4.412
6769	Minn. 181	3.287	2.75	15.66	2.65	2.31	77.26	2.12	4.465
6768	Minn. 851	3.372	2.82	16.10	2.45	2.50	76.62	2.33	4.461
	Average of 5	3.109	2.71	15.43	2.52	2.41	77.41	2.23	4.451

The results obtained in Aroostook county with the Blue Stem and the Minn. 181 wheats would, if taken by themselves and for a single season, seem to confirm the belief that the northwestern wheats quickly deteriorate when grown in Maine. If, however, these results are studied in connection with those obtained by a second planting and also by the check trials in Minnesota, it will be found that the results first obtained have lost much of their apparent significance.

The most important differences in these wheats is in the amount of protein which they contain and in the weights of the kernels. These differences are brought out more clearly in the table on the following page.

WEIGHTS OF KERNELS AND PERCENTAGES OF PROTEIN IN MINNESOTA PARENT WHEATS AND THEIR MAINE AND MINNESOTA GROWN PROGENY.

Laboratory number.		Water.	Weight of 100 Kernels.		Protein.	
			Air dry.	Water free.	Air dry.	Water free.
		Per cent.	Grams	Grams	Per cent.	Per cent.
6622	Parent grown in Northwest 1900	10.89	3.087	2.751	14.54	16.32
6617	From 6622 grown in Houlton 1901	13.58	3.329	2.877	11.01	12.76
6772	From 6622 grown in Houlton 1902	11.65	3.751	3.314	13.74	15.55
6770	From 6617 grown in Houlton 1902	11.77	3.435	3.031	13.74	15.57
6714	Parent grown in Minn. 1901	10.80	2.527	2.254	16.93	18.98
6774	Progeny grown in Minn. 1902	12.07	2.230	1.960	12.88	14.65
6769	Progeny grown in Maine 1902	12.27	3.748	3.287	13.74	15.66
6715	Parent grown in Minn. 1901	10.03	2.440	2.196	14.08	15.65
6775	Progeny grown in Minn. 1902	11.93	2.312	2.036	13.62	15.46
6768	Progeny grown in Maine 1902	12.53	3.860	3.372	14.08	16.10

The first of these trials with Blue Stem in Aroostook resulted in a loss of protein of nearly 4 per cent; yet on the following year a planting from the same seed and another from the original Minnesota wheat brought the protein back to within one per cent of the parent wheat. What the result from another planting might be, it is impossible to predict.

Equally inconclusive are the results obtained with the Minn. 181 wheat. This variety planted in Maine lost over 3 per cent in a single season; planted in Minnesota, it lost over 4 per cent. The Minn. 851 lost no protein when grown in Aroostook, although the western grown crop experienced a slight reduction.

These curiously varying results seem to admit but one safe conclusion, viz.: That merely temporary or extremely local conditions of season and soil may obscure or counterbalance a tendency the existence of which can be fully established only by

years of careful experimentation. It is evident that no collection of data like that given on page 155, in which wheats of one variety are compared with those of another, can cast any certain light upon the subject, and the only fair comparisons now available are those given on pp. 159 and 161. The general trend of these results, contradictory though they are, is in favor of the northwestern grown wheats. These have been found to contain on the average, in the water-free grain, 15.28 per cent of protein; while the Aroostook county wheats, grown from the same seed, contain 14.27 per cent of protein; a difference in favor of the former of 1.01 per cent.

Milling Experiments.

In conversation with the millers while obtaining the samples of flour described earlier in this bulletin, it was learned that they had very little notion as to the amount of wheat they used to make a barrel of flour. In order to study the losses in Maine milling two milling experiments were made at the Washburn mill. This mill and the services of the miller were kindly placed at our disposal by its owner, Mr. T. H. Phair of Presque Isle. The mill is a small one (20 barrels capacity), and at the time of the experiment newly erected, the miller had had very limited experience, and the wheats milled were hard wheats grown in the Northwest. For these reasons the test was not a fair measure of the work the mill can do, but it probably fairly represents the quality of flour and closeness of milling that was in practice there in the fall of 1900. With the erection of the new mill at Houlton and the employment of a skilled practical miller, the owners, E. Merritt & Sons, were sure they were doing work which would compare favorably with that of small mills in any part of the country. They kindly placed their mill and their miller at the services of the Station and five additional tests with native grown and northwestern grown wheat of several varieties were made. The "runs" were quite short and the milling was not as close as doubtless would have been the case if the time of the "runs" had been days instead of one or two hours. The baking tests were made for us by Mr. Foster, the expert of the Consolidated Milling Company of Minneapolis. The detailed statements of the milling experiments and the baking tests follow, together with a discussion of the results.

MILLING EXPERIMENT NO. I.

At Washburn. Wellman's Fife wheat from the Minnesota Experiment Station. The wheat used in the experiment weighed 1699 pounds. The results of the milling test, calculated for 100 pounds of wheat, and the analyses of the wheat and the milling products, are given in the tables which follow.

PRODUCTS OBTAINED AT WASHBURN, MAINE, FROM MILLING ONE HUNDRED POUNDS OF MINNESOTA GROWN WELLMAN'S FIFE WHEAT AND THE DISTRIBUTION OF NITROGEN THEREIN.

Laboratory number.	Wheat and Its Milling Products.		Distribution of Nitrogen.	
	Kind.	Amount.	By weight.	By per cent.
		Pounds.	Pounds.	Per cent.
6348	Wheat	100.0	2.06	100.0
6349	First grade flour	48.0	.88	42.3
6350	Second grade flour	8.6	.17	8.2
	Total flour	56.6	1.05	50.5
6351	Middlings	22.9	.52	25.0
6352	Bran	20.5	.51	24.5
	Total offals	43.4	1.03	49.5
	Total products	100.0	2.08	100.0

COMPOSITION OF MINNESOTA GROWN WELLMAN'S FIFE WHEAT AND MILLING PRODUCTS OBTAINED AT WASHBURN, MAINE, CALCULATED TO WATER CONTENT AT TIME OF MILLING AND TO THE WATER-FREE BASIS.

Laboratory number.	Wheat and Its Milling Products.	Water.	Nitrogen.	Protein (Nx6.7).	Fat.	Crude fiber.	N-free extract.	Ash.	Heat of combustion. Per gram.
	In Fresh Substance.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Calories.
6348	Wheat	12.80	2.06	11.74	2.53	2.46	68.35	2.12	3.956
6349	First grade flour	12.91	1.84	10.49	.96	.36	74.85	.43	3.864
6350	Second grade flour	12.65	1.92	10.94	1.22	.35	74.29	.55	3.875
6351	Middlings	11.98	2.29	13.05	3.42	2.54	66.71	2.30	4.003
6352	Bran	10.40	2.44	13.91	4.92	8.05	56.77	5.95	4.081
	In Dry Matter.								
6348	Wheat	.....	2.36	13.46	2.92	2.82	78.37	2.43	4.535
6349	First grade flour	.....	2.11	12.05	1.10	.41	85.95	.49	4.435
6350	Second grade flour	....	2.20	12.53	1.40	.40	85.04	.63	4.436
6351	Middlings	.....	2.60	14.82	3.89	2.89	75.79	2.61	4.547
6352	Bran	.....	2.72	15.55	5.47	2.98	69.36	6.64	4.535

MILLING EXPERIMENT NO. 2.

At Washburn. Haynes Blue Stem wheat from the Minnesota Experiment Station. The wheat used in this experiment weighed 1699 pounds. The results of the milling test, calculated for 100 pounds of wheat, and the analyses of the wheat and the milling products, are given in the tables which follow.

PRODUCTS OBTAINED AT WASHBURN, MAINE, FROM MILLING ONE HUNDRED POUNDS OF MINNESOTA GROWN HAYNES BLUE STEM WHEAT AND THE DISTRIBUTION OF NITROGEN THEREIN.

Laboratory number.	Wheat and its Milling Products.		Distribution of Nitrogen.	
	Kind.	Amount.	By weight.	By per cent.
		Pounds.	Pounds.	Per cent.
6355	Wheat	100.0	1.86	100.0
6356	First grade flour	49.5	.81	43.3
6357	Second grade flour	8.7	.15	80.0
	Total flour	58.2	.96	51.3
6358	Middlings	20.6	.43	23.0
6359	Bran	21.2	.48	25.7
	Total offal	41.8	.91	48.7
	Total products	100.0	1.87	100.0

COMPOSITION OF MINNESOTA GROWN HAYNES BLUE STEM WHEAT AND MILLING PRODUCTS OBTAINED AT WASHBURN, MAINE, CALCULATED TO WATER CONTENT AT TIME OF MILLING AND TO THE WATER-FREE BASIS.

Laboratory number.	Wheat and its Milling Products.	Water.	Nitrogen.	Protein (Nx5.7)	Fat.	Crude fiber.	N-free extract.	Ash.	Heat of combustion.
	In fresh substance.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Calories.
6355	Wheat	12.48	1.86	10.60	2.30	2.42	70.36	1.84	3.909
6356	First grade flour	13.57	1.64	9.35	1.09	.27	75.28	.44	3.805
6357	Second grade flour	13.37	1.74	9.92	1.38	.24	74.64	.45	3.845
6358	Middlings	13.18	2.11	12.03	3.62	2.56	66.56	2.05	3.967
6359	Bran	9.96	2.28	13.00	5.07	8.69	58.34	4.94	4.135
	In dry matter.								
6355	Wheat	....	2.13	12.11	2.63	2.76	80.40	2.10	4.462
5356	First grade flour	.....	1.90	10.83	1.26	.31	87.09	.51	4.402
6357	Second grade flour	.....	2.01	11.45	1.59	.28	86.16	.52	4.438
6358	Middlings	.....	2.43	13.85	4.15	2.95	76.69	2.36	4.569
6359	Bran	....	2.53	14.43	5.63	9.64	64.80	5.50	4.592

MILLING EXPERIMENT NO. 3.

At Houlton. Fife wheat grown in Maine in 1901, the progeny of seed brought from the Northwest in 1896. The wheat used in the experiment weighed 1619 pounds. The results of the milling test, calculated for 100 pounds of wheat, and the analyses of the wheat and the milling products, are given in the tables which follow.

PRODUCTS OBTAINED AT HOULTON, MAINE, FROM MILLING ONE HUNDRED POUNDS OF MAINE GROWN FIFE WHEAT AND THE DISTRIBUTION OF NITROGEN THEREIN.

Laboratory number.	Wheat and Its Products.		Distribution of Nitrogen.	
	Kind.	Amount.	By weight.	By per cent.
		Pounds.	Pounds.	Per cent.
6607	Wheat			
6608	Patent flour	100 0	1.87	100.0
6609	Second grade flour	55.8	.86	47.2
		15.0	.28	15.4
	Total flour	70.8	1.14	62.6
6610	Middlings	15.4	.39	21.4
6611	Bran	13.8	.29	16.0
	Total offals	29.2	.68	37.4
	Total products	100.0	1.82	100.0

COMPOSITION OF MAINE GROWN FIFE WHEAT AND MILLING PRODUCTS OBTAINED AT HOULTON, CALCULATED TO WATER CONTENT AT TIME OF MILLING AND TO THE WATER-FREE BASIS.

Laboratory number.	Wheat and Its Milling Products.	Water.	Nitrogen.	Protein (Nx5.7).	Fat.	Crude fiber.	N-free extract.	Ash.	Heat of combustion per gram.
	In Fresh Substance.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Calories.
6607	Wheat	11.48	1.87	10.66	2.34	1.96	71.64	1.92	3.886
6608	Patent flour	13.62	1.53	8.72	1.09	.16	75.97	.44	3.723
6609	Second grade flour	12.70	1.83	10.43	2.15	.37	73.30	1.05	3.824
6610	Shorts	10.10	2.49	14.20	5.71	4.86	61.19	3.94	4.118
6611	Bran	10.27	2.11	12.03	4.72	9.37	57.64	5.97	4.041
	In Dry Matter.								
6607	Wheat	.....	2.11	12.04	2.64	2.21	80.94	2.17	4.390
6608	Patent flour	.....	1.77	10.10	1.26	.19	87.94	.51	4.310
6609	Second grade flour	.....	2.10	11.95	2.46	.42	83.97	1.20	4.380
6610	Shorts	.....	2.77	15.80	6.35	5.41	68.06	4.38	4.581
6611	Bran	.....	2.35	13.41	5.26	10.44	64.24	6.65	4.504

MILLING EXPERIMENT NO. 4.

At Houlton. White Russian wheat that has been grown in Aroostook county for many years. The wheat used in this experiment weighed 840 pounds. The result of the milling test, calculated for 100 pounds of wheat, and the analyses of the wheat and the milling products, are given in the tables which follow.

PRODUCTS OBTAINED AT HOULTON, MAINE FROM MILLING ONE HUNDRED POUNDS OF MAINE GROWN WHITE RUSSIAN WHEAT AND THE DISTRIBUTION OF NITROGEN THEREIN.

Laboratory number.	Wheat and its Milling Products.		Distribution of Nitrogen.	
	Kind.	Amount.	By weight.	By per cent.
		Pounds.	Pounds.	Per cent.
6612	Wheat	100.0	1.85	100.0
6613	Patent flour	54.0	.82	44.3
6614	Second grade flour	16.2	.29	15.7
	Total flour	70.2	1.11	60.0
6615	Middlings	12.6	.34	18.4
6616	Bran	17.2	.40	21.6
	Total offals	29.8	.74	40.0
	Total products	100.0	1.85	100.0

COMPOSITION OF MAINE GROWN WHITE RUSSIAN WHEAT AND MILLING PRODUCTS OBTAINED AT HOULTON, MAINE, CALCULATED TO WATER CONTENT AT TIME OF MILLING AND TO WATER-FREE BASIS.

Laboratory number.	Wheat and its Milling Products.	Water.	Nitrogen.	Protein (Nx5.7)	Fat.	Crude fiber.	N-free extract.	Ash.	Heat of combustion per gram.
	In fresh substance.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Calories.
6612	Wheat	11.82	1.85	10.54	2.18	1.92	71.90	1.64	3.852
6613	Patent flour	14.84	1.51	8.61	.79	.24	75.20	.32	3.660
6614	Second grade flour	15.20	1.77	10.09	.63	.39	72.98	.71	3.639
6615	Shorts	10.79	2.65	15.10	5.59	5.00	60.07	3.45	4.149
6616	Bran	11.38	2.31	13.17	3.92	8.23	58.22	5.08	4.015
	In dry matter.								
6612	Wheat	.....	2.10	11.95	2.47	2.18	81 54	1.86	4.368
6613	Patent flour	.....	1.77	10.11	.93	.28	88.30	.38	4.298
6614	Second grade flour	.....	2.09	11.90	.74	.46	86.06	.84	4.291
6615	Shorts	.....	2.97	16.93	6.27	5.60	67.33	3.87	4.651
6616	Bran	.....	2.61	14.86	4.42	9.29	65.70	5.73	4.531

MILLING EXPERIMENT NO. 5.

At Houlton. Maine grown Blue Stem wheat, the progeny of the wheat (No. 6622) used in milling experiment No. 6. The wheat used in the experiment weighed 837 pounds. The results of the milling test, calculated for 100 pounds of wheat, and the analyses of the wheat and the milling products, are given in the tables which follow.

PRODUCTS OBTAINED AT HOULTON, MAINE, FROM MILLING ONE HUNDRED POUNDS OF MAINE GROWN BLUE STEM WHEAT AND THE DISTRIBUTION OF NITROGEN THEREIN.

Laboratory number.	Wheat and Its Milling Products.		Distribution of Nitrogen.	
	Kind.	Amount.	By weight.	By per cent.
		Pounds.	Pounds.	Per cent.
6617	Wheat	100.0	1.93	100.0
6618	Patent flour	56.3	.98	50.5
6619	Second grade flour	16.1	.31	16.0
	Total flour	72.4	1.29	66.5
6620	Middlings	14.4	.35	18.0
6621	Bran	13.2	.30	15.5
	Total offals	27.6	.65	33.5
	Total products	100.0	1.94	100.0

COMPOSITION OF MAINE GROWN BLUE STEM WHEAT AND MILLING PRODUCTS OBTAINED AT HOULTON, MAINE, CALCULATED TO WATER CONTENT AT TIME OF MILLING AND TO THE WATER-FREE BASIS.

Laboratory number.	Wheat and Its Milling Products.	Water.	Nitrogen.	Protein (Nx5.7).	Fat.	Crude fiber.	N-free extract.	Ash.	Heat of combustion per gram.
	In Fresh Substance.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Calories.
6617	Wheat	13.58	1.89	11.01	2.14	2.14	69.53	1.60	3.823
6618	Patent flour	13.57	1.75	9.97	1.21	.25	74.47	.53	3.743
6619	Second grade flour	13.68	1.95	11.11	.51	.42	73.39	.89	3.706
6620	Shorts	13.45	2.47	14.08	1.28	5.09	62.55	3.55	3.664
6621	Bran	13.23	2.27	12.94	1.79	10.56	55.88	5.60	3.815
	In Dry Matter.								
6617	Wheat	.....	2.18	12.76	2.48	2.48	80.43	1.85	5.003
6618	Patent flour	.....	2.02	11.53	1.40	.29	86.17	.61	4.321
6619	Second grade flour	.....	2.26	12.90	.58	.49	85.01	1.02	4.298
6620	Shorts	.....	2.85	16.27	1.48	5.88	72.27	4.10	4.234
6621	Bran	.....	2.62	14.92	2.06	12.17	64.40	6.45	4.397

MILLING EXPERIMENT NO. 6.

At Houlton. Blue Stem wheat grown in the Northwest and imported by E. Merritt & Sons in 1901. This wheat is the parent of that (No. 6617) used in milling experiment No. 5. The wheat used in the experiment weighed 898 pounds. The result of the milling test, calculated for 100 pounds of wheat, and the analyses of the wheat and the milling products, are given in the tables which follow.

PRODUCTS OBTAINED AT HOULTON, MAINE, FROM MILLING ONE HUNDRED POUNDS OF NORTHWESTERN GROWN BLUE STEM WHEAT AND THE DISTRIBUTION OF NITROGEN THEREIN.

Laboratory number.	Wheat and its Milling Products.		Distribution of Nitrogen.	
	Kind.	Amount.	By weight.	By per cent.
		Pounds.	Pounds.	Per cent.
6622	Wheat	100.0	2.55	100.0
6623	Patent flour	57.5	1.31	52.4
6624	Second grade flour	15.3	.39	15.6
	Total flour	72.8	1.70	68.0
6625	Middlings	13.1	.38	15.2
6626	Bran	14.1	.42	16.8
	Total offals	27.2	.80	32.0
	Total products	100.0	2.50	100.0

COMPOSITION OF NORTHWESTERN GROWN BLUE STEM WHEAT AND MILLING PRODUCTS OBTAINED AT HOULTON, MAINE, CALCULATED TO WATER CONTENT AT TIME OF MILLING AND TO THE WATER FREE BASIS,

Laboratory number.	Wheat and its Milling Products.	Water.	Nitrogen.	Protein (Nx5.7)	Fat.	Crude fiber.	N-free extract.	Ash.	Heats of combustion per gram.
	In fresh substance.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Calories.
6622	Wheat	10.89	2.55	14.53	2.11	2.17	68.43	1.87	3.936
6623	Patent flour	12.19	2.27	12.94	1.04	.19	73.12	.52	3.831
6624	Second grade flour	12.44	2.53	14.43	2.03	.45	69.65	1.00	3.886
6625	Shorts	10.34	2.91	16.59	5.17	5.04	58.79	4.07	4.083
6626	Bran	8.51	2.93	16.70	4.00	9.29	55.51	5.99	4.075
	In dry matter.								
6622	Wheat	.....	2.86	16.30	2.37	2.43	76.80	2.10	4.417
6623	Patent flour	.....	2.59	14.74	1.18	.22	83.27	.59	4.363
6624	Second grade flour	.....	2.89	16.48	2.32	.51	79.55	1.14	4.438
6625	Shorts	.....	3.24	18.49	5.77	5.62	65.58	4.54	4.554
6626	Bran	.....	3.20	18.25	4.37	10.15	60.68	6.55	4.454

MILLING EXPERIMENT NO. 7.

At Houlton. Northwestern grown No. 2 wheat imported by E. Merritt & Sons in 1902. The wheat used in the experiment weighed 804 pounds. The results of the milling test, calculated for 100 pounds of wheat, and the analyses of the wheat and the milling products, are given in the tables which follow.

PRODUCTS OBTAINED AT HOULTON, MAINE, FROM MILLING ONE HUNDRED POUNDS OF NORTHWESTERN GROWN NUMBER TWO WHEAT AND THE DISTRIBUTION OF NITROGEN THEREIN.

Laboratory number.	Wheat and its Milling Products.		Distribution of Nitrogen.	
	Kind.	Amount.	By weight.	By per cent.
		Pounds.	Pounds.	Per cent.
6627	Wheat	100.0	2.29	100.0
6628	Patent flour	54.1	1.10	47.6
6629	Second grade flour	14.3	.33	14.3
	Total flour	68.4	1.43	61.9
6630	Middlings	11.2	.34	14.7
6631	Bran	20 4	.54	23.4
	Total offals	31.6	.88	38.1
	Total products	100.0	2.31	100.0

COMPOSITION OF NORTHWESTERN GROWN NUMBER TWO WHEAT AND MILLING PRODUCTS OBTAINED AT HOULTON, MAINE, CALCULATED TO WATER CONTENT AT TIME OF MILLING AND TO WATER-FREE BASIS.

Laboratory number.	Wheat and its Milling Products.	Water.	Nitrogen.	Protein (Nx5.7)	Fat.	Crude fiber.	N-free extract.	Ash.	Heat of combustion per gram.
	In fresh substance.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Calories.
6627	Wheat	11.39	2.29	13.05	2.32	2.35	68.91	1.98	3.823
6628	Patent flour	12.13	2.05	11.69	1.12	.18	74.52	.36	3.812
6629	Second grade flour	12.14	2.35	13.40	2.30	.48	70.48	1.20	3.831
6630	Shorts	10.22	3.05	17.39	5.72	4.79	57.72	4.16	4.112
6631	Bran	8.31	2.67	15.22	4.48	8.48	58.00	5.51	4.109
	In dry matter.								
6627	Wheat	.....	2.58	14.73	2.62	2.65	77.77	2.23	4.315
6628	Patent flour	. . .	2.33	13.30	1.27	.20	84.82	.41	4.339
6629	Second grade flour	.....	2.68	15.25	2 62	.55	80.22	1.36	4.360
6630	Shorts	.....	3.40	19.37	6.37	5.34	64.29	4.63	4.580
6631	Bran	.....	2.91	16.60	4.89	9.25	63.25	6.01	4.482

accords quite closely to his standard of a hard flour. The second grade flours, Nos. 6383 and 6385, are equally recognized and so classed.

The Staten Island first quality flour (No. 6384) and the Cataract best patent (No. 6386), while agreeing with the standard in color and gluten, make loaves very much like the patents milled at Washburn (Nos. 6349 and 6356). The three flours from Maine grown wheats milled at Houlton (Nos. 6608, 6613 and 6618) are low in gluten and make small loaves which weigh considerably more than the standard. For example, 100 pounds of flour of No. 6618 would make a twelfth greater weight of bread than 100 pounds of the standard, but this bread would be much closer in texture and on that account less pleasing to the eye and less open to the action of digestive juices when eaten. Flours Nos. 6608 and 6613 were ground too fine for the Minneapolis standard, while Nos. 6618 and 6628 were just right. The flours from the two Minnesota wheats (Nos. 6623 and 6628) are high in gluten and make good loaves. Mr. Foster attributed the dark color of No. 6623 to the dryness of the wheat at the time of milling, which caused particles of the bran to appear in the early breaks and which could not be subsequently eliminated.

The Kansas flour (No. 6605) comes but little nearer the Minneapolis standard than those milled in Maine from Maine grown wheat. The arbitrary nature of the standard and the fact that it is applicable only to the hard wheats of the Northwest, thus becomes very evident. These wheats are so abundant that they largely regulate the ideals of the flour market and to successfully compete flour must more or less correspond to the standard. Still there is plenty of room in such a district as Aroostook county to develop the growing and the milling of wheat along its own lines. The experiments at Houlton show that most of the flour can be obtained from the wheat in our own mills. The appearance of flours Nos. 6618 and 6628 show that we can make a flour equal in that respect (and 6618 was from a Maine grown wheat) to the western flour. There is little question but that by careful breeding from wheat now being grown in Maine it would be possible to develop a strain equal for our conditions to some of the improved strains of other sections. The improvment must come, if it comes at all, by careful attention to the details of wheat breeding and wheat milling.

The Improvement of Wheat.

There are two comparatively easy ways in which trials can be made to improve the wheat grown in Aroostook county. The first and one which most naturally suggests itself is the introduction of new seed wheat from other localities; the other is the improvement by selection from wheat now grown in the county. The former plan is that tried by the Station and recorded in the preceding pages. Because of the great difference in climate between Maine and the Northwest, the varieties introduced speedily changed their character so that at the end of a single season they had become relatively much richer in starch. To the writers it seems that there is greater hope in the improvement of the quality of Aroostook county wheat by careful selection from wheat already grown in the county than by the introduction of seed from other localities. Not only are there several varieties of wheat now grown in Aroostook county, but these varieties differ among themselves in earliness, productiveness and capacity for making good flour. Furthermore, there will be found to be great variation in individual plants of wheat from the same lot. For example, careful examination of any field of wheat will show that occasional plants mature earlier than other plants; that some plants are taller and stockier than other plants; and that some plants will carry more and heavier kernels of wheat than others. This variability of individual plants can be used as a basis for improvement of wheat by selection.

The Minnesota Experiment Station has given much study to the methods of breeding, selecting and improvement of wheats,* and the following suggestions are based upon the results of their studies.

The first step in breeding would be to select from an Aroostook grown wheat of a good variety about 1000 of the hardest, heaviest kernels. These should be planted in carefully prepared ground singly in hills four inches apart each way. For convenience of working, these hills should be planted in beds not more than three feet wide. The soil should be kept free from weeds during the growing season and care should be taken that if by

* Bulletin 62, Minnesota Experiment Station.

chance two seeds have been dropped in the same place that only one plant be allowed to grow. As the two outer rows will have had greater exposure to sunlight and air than the inner ones, these plants should be cut off with shears and thrown away, just before harvesting. At the time of harvest 100 of what seem to be the best plants should be selected and the spikes cut off without any straw. These can be conveniently stored in a paper bag. The remainder of the plot can be harvested and stored in another paper bag in the same way. The seeds from these selected best heads should be sown the following season in another seed bed by themselves. The seeds from the about 900 plants which are harvested by themselves can, after being hand shelled, be picked over and 1000 seeds selected, planted and treated in the same way as in the preceding season.

While this seems laborious and a slow process, in the course of three or four years there will have been obtained several lots of seeds, sufficient to sow 1-20 of an acre each, which will give a sufficient crop to make a milling test of the wheat.

THE PLANT HOUSE ALEYRODES

Bulletin No. 96 of this Station consists of a scientific and technical description of the greenhouse aleyrodes, (*Aleyrodes vaporariorum,* Westw.). As the bulletin is not of general interest, only a limited edition was printed and it will be sent only on application.

The plant house aleyrodes is a small insect which during the summer lives chiefly out of doors on garden plants. In the fall the larvæ and pupæ are brought into the greenhouse with the plants and some of the adults fly in. Here they begin to breed as soon as crops are started, multiplying fast enough to keep pace with the growth of the plants.

Spraying with various solutions and fumigating with tobacco are among the remedies oftenest recommended for this insect. At this Station fumigating with hydrocyanic gas was the most successful remedy tried.